

HABITAT OF THREATENED PROTEACEAE ENDEMIC TO WESTERN CAPE COASTAL FLATS

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ABSTRACT

Serruria ciliata, *Diastella buekii* and four species of *Leucadendron* are among members of the family Proteaceae endemic to the western coastal flats of the south-western Cape. These six species are associated with types of Coastal Fynbos or Coastal Rhenosterbosveld. Their habitats are compared using associated plants (Proteaceae and Restionaceae) as an expression of environmental conditions.

UITTREKSEL

HABITAT VAN BEDREIGDE PROTEACEAE ENDEMIES AAN DIE WESTELIKE KAAPSE KUSVLAKTES

Serruria ciliata, *Diastella buekii* en vier *Leucadendron* spesies is voorbeelde van lede van die familie Proteaceae wat beperkte verspreidings op die westelike kusvlakte van suidwes-Kaapland het. Hierdie ses spesies kom op verskillende tipes kusfynbos of kusrenosterbosveld voor. Hul habitate word met mekaar vergelyk op grond van geassosieerde plantsoorte (Proteaceae en Restionaceae) as weerspieëling van omgewingstoestande.

INTRODUCTION

The area occupied by natural vegetation on the western coastal flats of the south-western Cape (a land-unit, defined by Milewski & Esterhuysen, 1977), corresponding roughly to the western blocks of Acocks' [1975] Coastal Rhenosterbosveld and Coastal Macchia and the Breërivier valley east to Worcester) has been severely fragmented by man-made environmental changes. Several naturally rare plant species restricted to this area survive today only as relict populations and are threatened with extinction (Rare and Endangered Species Research Group, unpublished; Milewski & Esterhuysen, 1977). Knowledge of the phytogeographical relationships and habitats (*sensu* Whittaker *et al.*, 1973) of these localized habitat-specific endemics is an urgent prerequisite for their conservation.

This paper attempts a comparison of the habitats of several threatened endemic species in the family Proteaceae by a qualitative floristic method, using a sample of the plant taxa associated with each in its natural environment. Assumptions

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basic to this exploratory approach, which was similar to that of Milewski and Esterhuysen (1977) and Milewski (1977) were:

- (i) that the set of plant species growing at a site is an adequate and easily documented reflection of local environment in fynbos; the number of species in a given stand of this vegetation is relatively large (Taylor, in press), permitting more detailed characterisation of habitats by a floristic method than might be possible in vegetation dominated by another flora,
- (ii) that data on presence and absence of species are suitable and sufficient for such characterisation, in view of the high species-diversity in fynbos and the possibility that the relative importances of species have been changed by man-made disturbance, and
- (iii) that two families characteristic of fynbos (Taylor, in press), the Proteaceae and Restionaceae, constitute a representative sample of the taxa composing the vegetation and are sufficient for characterisation of habitats for comparative purposes.

Additional considerations leading to the choice of the Proteaceae as a sample group were that the study species are members of this family and that most genera are, or have already been, under taxonomic revision. The Restionaceae were in turn chosen partly because representatives of the family are invariably present in and thus characterise fynbos, and partly because the apparent habitat specificity of members of this large group makes them useful indicators of environment (Taylor, 1969, 1972a, in press; Boucher, 1972; Milewski & Esterhuysen, 1977).

The family Proteaceae is represented on the western flats of the south-western Cape by twelve species of *Leucadendron*, six species of *Leucospermum*, ten species of *Serruria*, three species of *Diastella* and six species of *Protea*. The following is a brief outline of the phytogeography of these groups in relation to the overall phytogeography of these flats.

Leucadendron salignum occupies the major part of the western flats and is widespread throughout the south-western Cape. The remaining 11 *Leucadendron* species occurring on the flats are all endemic, extending neither on to adjacent mountains nor on to the southern coastal flats east of Hangklip. *Leucadendron floridum*, *L. thymifolium*, *L. levisanus*, *L. verticillatum* and *L. flexuosum*, and the extinct *L. spirale*, have or had small, continuous areas of distribution. *Leucadendron lanigerum*, *L. corymbosum*, *L. cinereum*, *L. stellare* and *L. foedum* have wider ranges, those of *L. stellare*, *L. corymbosum* and *L. lanigerum* being disjunct. In addition to these 12 species, *Leucadendron chamelaeae*, *L. linifolium*, *L. brunoides*, *L. rubrum* and *L. spissifolium* extend marginally on to the flats from their main ranges elsewhere (Williams, 1972).

Three species of *Leucospermum*, viz. *L. parile*, *L. arenarium* and *L. tomentosum*, are endemic to small, continuous areas of distribution on the western flats. *Leucospermum hypophyllocarpodendron* and *L. rodolentum* have wider, disjunct

ranges centred on, but not restricted to, the flats. *Leucospermum grandiflorum* has a small range on part of the flats and adjacent foothills. In addition to these six species, *L. conocarpodendron* and *L. calligerum* extend marginally on to the flats from their main ranges on the mountains (Rourke, 1972).

Serruria burmannii parallels *Leucadendron salignum* as a widespread inhabitant of most of the western flats. *Serruria ciliata*, *S. trilopha*, *S. furcellata*, *S. linearis* and *S. roxburghii* are all endemic to the flats, having small areas of distribution; *S. decipiens* has a wider range but appears also to be endemic. *Serruria incrassata*, *S. aitonii*, *S. glomerata*, *S. cyanoides* and *S. brownii* occupy part of the flats and extend on to the adjacent foothills. In addition, *S. vallis* and possibly also *S. fucifolia*, both mountain species, extend marginally on to the flats (Rourke, in prep.).

Diastella parilis and *D. buekii* have small ranges on the flats adjacent to the foothills. *Diastella proteoides*, also endemic, has a wider distribution. In addition, *D. divaricata* has a range centred on the mountains and extending marginally on to the flats (Rourke, 1976).

Protea repens is a widespread member of its genus on the western flats, as are *Leucadendron salignum* and *Serruria burmannii*. *Protea pulchra* and *P. acaulos* also occupy the major part of the flats but extend on to the adjacent mountains. *Protea scolymocephala*, *P. odorata* and *P. mucronifolia* are endemic, *P. scolymocephala* having a wide range relative to the other two species. In addition, *P. arborea*, *P. laurifolia*, *P. cynaroides*, *P. lepidocarpodendron* and *P. macrocephala*, all mountain species, occur marginally on the flats (Rourke, in prep.).

Studies of Restionaceae (Milewski & Esterhuysen, 1977; Milewski, 1977) represent virtually the only available phytogeographical information dealing specifically with the western flats. Weimarck (1941), working with preliminary distribution data for a number of sample groups over the entire south-western Cape, treated this area merely as part of his "South-Western Centre", a phytogeographical land unit comprising both mountains and flats south and west of the Breede and Berg Rivers. He minimised the phytogeographical distinctiveness of these flats in comparison with surrounding mountains and the Bredasdorp limestone flats, stating: "The species occurring here have, as a rule, large distribution areas and are also abundant in a large part of the flats", and citing *Corymbium salteri*, *Echiostachys spicatus* and *Lobostemon paniculaeformis* as examples of the "very few" endemic species (Weimarck, 1941).

The restriction of three Restionaceous (Milewski & Esterhuysen, 1977) and 23 Proteaceous (above) species to the western flats calls for a revision of Weimarck's preliminary interpretation. The combination of an evident concentration of endemic taxa and intensive disturbance by man makes the western coastal flats a priority area for research towards plant conservation. Williams (1972), referring to *Leucadendron floridum*, stated: "There is no doubt that, unless this historic species is rigorously preserved, it will be extinct before long. It has already been

eliminated everywhere except in the Cape Point Nature Reserve, . . . where it is now being rapidly overwhelmed by the introduced Australian Port Jackson wattle [*Acacia saligna* Wendl., formerly *A. cyanophylla* Lindl.].” *Leucadendron levisanus*, another flats endemic, was formerly “abundant” near Cape Town: “urban development and the spread of the introduced *Acacia cyanophylla* Lindl., have however virtually eliminated it from the Peninsula and it is fast approaching extinction” (Williams, 1972).

METHODS

Six study species in the family Proteaceae were chosen for the following characteristics:

- (1) endemism to a small continuous geographical range (maximum 700 km²) within the western coastal flats, arbitrarily defined (Milewski & Esterhuysen, 1977) as from False Bay northwards, west of the Hottentots-Holland-Winterhoek mountain chain to S 32 ° 30' and eastwards along the intermontane flats to Worcester, between sea level and 600 m altitude, and
- (2) small size and deteriorating conservation status of remaining total species-population owing to man-made environmental changes (number of known extant plants of each study species less than 1 000).

The study species, all evergreen perennials, were:

- (i) *Serruria ciliata* R. Br.,
- (ii) *Leucadendron verticillatum* (Thunb.) Meisner,
- (iii) *Leucadendron flexuosum* Williams,
- (iv) *Leucadendron floridum* R. Br.,
- (v) *Leucadendron levisanus* (L.) Berg., and
- (vi) *Diastella buekii* (Gandoger) Rourke.

Methods were essentially similar to those used by Milewski (1977). Severe limitations on the thoroughness of the investigation were imposed by the study species' relict status. All known remaining populations of each study species were investigated, “populations” of a species being arbitrarily defined (Milewski & Esterhuysen, 1977) as stands farther than 2 km apart. Data were recorded from two populations of all study species except *Diastella buekii* (until recently thought extinct [Rourke, 1976]; a single rediscovered population was investigated) and *Leucadendron verticillatum* (3 populations investigated). The physiognomy and general floristics of associated vegetation were subjectively recorded for each population.

Indirect (floristic) information was mainly used in comparing the habitats of the study species. The four *Leucadendron* species grow as 1,0–2,0 m high, densely branched, erect woody shrubs arising from a single stem; the two *Serruria* species, forming 0,5–1,0 m high shrubs, have similar growth-form. *Diastella*

buekii grows as a dense "mat" (diameter 1.0–2.0 m) of creeping soft-woody stems, originating from a single base at ground level and rooting adventitiously. All species in the Proteaceae and Restionaceae growing within 0.5 m of plants of each study species were recorded, data thereby being collected only within the edaphic environment of the study species (plants of the study species cover a larger area than do the herbaceous Restionaceous species studied by Milewski, 1977, necessitating a greater radius of investigation).

The search for members of these two families was continued until the list of associates for each population appeared complete, i.e. until not more than one new associate species was found with ten successively visited study plants, or until a minimum of 20 plants, scattered throughout the population, had been investigated. Lists, according to presence or absence, of associate species for each population were combined to show the "between-population frequency" of each associate for each study species. A list from one population of *Serruria ciliata* (apparently var. *congesta*) was not included in the associate data, since the associated vegetation appeared very different from that in which the typical form of the species grew, and owing to the undecided taxonomic status of *S. ciliata* var. *congesta* at the time of writing (Rourke, pers. comm.).

RESULTS AND DISCUSSION

1. General account of habitats

Serruria ciliata was restricted to deep, pale Tertiary sand on the northern Cape Flats (Rourke, in prep.). The associated vegetation was a mainly restioid-ericoid (*sensu* Taylor, in press) Coastal Fynbos, 1.0–1.5 m high. The species occurred near Bellville and Bottelary as scattered plants with e.g. *Berzelia abrotanoides*, *Staavia adriata*, *Cliffortia polygonifolia* and *Passerina vulgaris* in stands similar to those associated with *Chondropetalum acockii* and *Restio micans* (Milewski & Esterhuysen, 1977). *Serruria ciliata* var. *congesta* grew near Faure in vegetation different in appearance, resembling Taylor's (1972b) *Thamnochortus-Passerina* Fynbos of Reddish Sands, with the ericoid shrub *Passerina vulgaris*, the tufted restioid *Thamnochortus erectus*, the low spreading shrub *Myrica quercifolia* and several members of the Proteaceae and Restionaceae (Appendix 1).

Leucadendron verticillatum was restricted to "fairly level" substrates "with a clay subsoil" in "a small area where the divisions of Bellville, Paarl, Malmesbury and Stellenbosch adjoin each other" (Williams, 1972). The associated vegetation was an ericoid-restioid form of Coastal Rhenosterbosveld (*sensu* Taylor, in press). The species occurred on the slopes of the Joostenberg as scattered emergent plants in an open stand (canopy cover 40–50%) comprising a main 0.7–0.9 m stratum dominated by the "heath-like" shrub *Elytropappus rhinocerotis*, and a ground stratum of wiry restioids (e.g. *Restio cuspidatus*) and forbs. *Leucadendron verticillatum* occurred near Hercules Pillar as 2.5–3.0 m emergent shrubs in similar

vegetation, with 1,0–1,5 m proteoid (*Leucadendron lanigerum*), broad-leaved (e.g. *Olea africana*) and ericoid (e.g. *Eriocephalus africanus*) shrubs.

Leucadendron flexuosum occurred only on "level alluvial soil containing a large percentage of waterworn stones" in a small area of "the Breede River Valley near Worcester" (Williams, 1972). The associated vegetation was an ericoid-restioid dry fynbos. The species grew near Hartebeest River Bridge as scattered plants forming a 1,8 m emergent stratum in an open stand (canopy cover 40–50 %) comprising a main 0,3–0,4 m stratum of ericoid and other small-leaved shrubs (e.g. *Elytropappus gnaphaloides*, *Eriocephalus africanus*, *Relbania squarrosa*, *Cliffortia ruscifolia*) and wiry restioids (e.g. *Restio cuspidatus*). Another population of *Leucadendron flexuosum* near Hartebeest River Bridge occurred as groups of plants forming, with shrubs of *Dodonaea viscosa*, a 1,0 m stratum emergent from a main stratum of tufted restioids (e.g. *Thamnochortus sporadicus*) and ericoid shrubs.

Leucadendron floridum was restricted to sandy soil on the Cape Flats and valleys of the Cape Peninsula (Williams, 1972). The associated vegetation was a mainly graminoid-ericoid (*sensu* Taylor, in press) fynbos intermediate in appearance between Coastal Fynbos and Mountain Fynbos. The species occurred near Kommetjie and between Scarborough and Klaarsjagersberg in dense stands (canopy cover 80–90 %), comprising 1,0–2,0 m high tussock restioids (e.g. *Restio compressus*) and other graminoids (e.g. *Neesenbeckia punctata*), and ericoid and other shrubs (e.g. *Berzelia abrotanoides*, *Erica* spp., *Psoralea aphylla*), and a poorly defined lower stratum of sprawling soft shrubs (e.g. *Cliffortia subsetacea*) and tufted restioids (e.g. *Elegia fistulosa*). This vegetation appeared similar to Taylor's (1969) *Berzelia-Osmitopsis* Seepage Scrub Association and *Restionaceus* Tussock Marsh Association.

Leucadendron levisanus occurred only "on sandy soil . . . on the Cape Flats from the Fish Hoek valley north to the Koeberg" (Williams, 1972). The species formed a scattered emergent stratum of 1,0–1,5 m shrubs in restioid-ericoid vegetation similar to that associated with *Serruria ciliata*. *Leucadendron levisanus* has previously been recorded growing with other emergents, e.g. *Thamnochortus erectus* and *Passerina vulgaris*, among plants of e.g. *Aspalathus hispida*, *Carpobrotus acinaciformis*, *Crassula cymosa*, *Psoralea fruticans*, *Rhus laevigata* and *Ehrharta villosa* (Taylor, 1972b).

Diastella buekii was restricted to "sandy situations", on "the floor of the upper Berg River valley" (Rourke, 1976). The associated vegetation was a mainly restioid-ericoid fynbos intermediate in appearance between Coastal Fynbos and Mountain Fynbos. The species occurred near Wemmershoek as scattered plants in an open stand (canopy cover 50–70 %) comprising a main 0,6–0,7 m stratum of tufted restioids (e.g. *Thamnochortus sporadicus*, *Chondropetalum nudum*, *Staberoha cernua*) and ericoid shrubs (e.g. *Cliffortia juniperina*, *Lachnospermum fasciculatum*, *Euryops abrotanifolius*, *Lachnaea capitata*, *Phylica stipu-*

TABLE 1

Restionaceous and Proteaceous associate species, according to "between-population frequency", of six Proteaceous study species: 1 = *Leucadendron floridum*, 2 = *Leucadendron levisanus*, 3 = *Serruria ciliata*, 4 = *Diastella buekii*, 5 = *Leucadendron flexuosum*, 6 = *Leucadendron verticillatum*. Numerator is the number of populations in which the associate was recorded within 0.5 m of plants of each study species; denominator is the total number of investigated populations of each study species; "+" indicates associates recorded in the same stand of vegetation as the study species but not within 0.5 m.

Associate species	Occurrence with study species					
	1	2	3	4	5	6
<i>Elegia fistulosa</i> Kunth	1/2					
<i>Restio compressus</i> Rottb.	2/2					
<i>Diastella divaricata</i> (Berg.) Rourke	1/2					
<i>Leucadendron laureolum</i> (Lam.) Fourcade	1/2					
<i>Restio dodii</i> Pillans	1/2					
<i>Elegia cuspidata</i> Mast.	1/2					
<i>Elegia asperiflora</i> (Nees) Kunth	2/2	+				
<i>Serruria glomerata</i> (L.) R.Br.	2/2	1/2				
<i>Restio tetragonus</i> Thunb.	2/2	1/2				
<i>Serruria ciliata</i> R.Br.		1/2				
<i>Restio triticeus</i> Rottb.		1/2				
<i>Elegia verreauxii</i> Mast.		+				
<i>Elegia prominens</i> Pillans		+				
<i>Restio sabulosus</i> Pillans		+				
<i>Protea scolymocephala</i> Reich.		+	+			
<i>Restio micans</i> (Kunth) Nees		1/2	1/2			
<i>Thamnochortus punctatus</i> Pillans		1/2	1/2			
<i>Diastella proteoides</i> (L.) Druce		+	1/2			
<i>Leptocarpus impolitus</i> (Kunth) Pillans			2/2			
<i>Leucadendron levisanus</i> (L.) Berg.			1/2			
<i>Leucadendron cinereum</i> (Solander ex Ait) R.Br.			1/2			
<i>Chondropetalum acockii</i> Pillans			1/2			
<i>Thamnochortus obiusus</i> Pillans			1/2			
<i>Protea pulchra</i> Rycroft			1/2			
<i>Staberoha distachya</i> (Rottb.) Kunth			1/2			
<i>Protea repens</i> (L.) L.			+			
<i>Serruria furcellata</i> R.Br.			+			
<i>Leucospermum hypophyllocarpodendron</i> (L.) Druce			2/2	1/1		
<i>Hypodiscus aristatus</i> (Thunb.) Nees			+	1/1		
<i>Restio curviramis</i> Kunth				1/1		
<i>Restio filiformis</i> Poir.				1/1		
<i>Restio pedicellatus</i> Mast.				1/1		
<i>Restio monanthus</i> Mast.				1/1		
<i>Restio wallichii</i> Mast.				+		
<i>Thamnochortus sporadicus</i> Pillans				1/1	2/2	
<i>Restio</i> sp. nov. 1				+	2/2	
<i>Cannomois acuminata</i> (Thunb.) Pillans					2/2	
<i>Leucospermum calligerum</i> (Salisb. ex Knight) Rourke					1/2	
<i>Leucadendron brunioides</i> Meisn.					+	

TABLE 1 (contd)

Associate species	Occurrence with study species					
	1	2	3	4	5	6
<i>Leucadendron chamelae</i> (Lam.) Williams					+	
<i>Thamnochortus bachmannii</i> Mast.					1/2	+
<i>Restio duthieae</i> Pillans						3/3
<i>Leucadendron lanigerum</i> Buek ex Meisn.						2/3
<i>Elegia squamosa</i> Mast.						2/3
<i>Hypodiscus paludosus</i> Pillans						2/3
<i>Elegia</i> sp. nov. Esterhuysen 34411						2/3
<i>Restio triflorus</i> Rottb.						2/3
<i>Protea odorata</i> Thunb.						1/3
<i>Restio quinquefarius</i> Nees	2/2	1/2	1/2			
<i>Restio bifurcus</i> Nees ex Mast.	1/2	1/2	1/2			
<i>Chondropetalum nudum</i> (Nees) Rottb.	2/2	2/2	+	1/1		
<i>Elegia vaginulata</i> Mast.	2/2		+	1/1		
<i>Elegia neesii</i> (Mast.) Mast.	2/2			1/1		
<i>Elegia coleura</i> Nees ex Mast.	1/2				1/2	
<i>Chondropetalum tectorum</i> (L.) Pillans		1/2	1/2			
<i>Willdenowia sulcata</i> Mast.		+	2/2	1/1		
<i>Willdenowia humilis</i> Mast.		+	1/2	1/1		
<i>Hypodiscus willdenowia</i> (Nees) Mast.		+	1/2	1/1		
<i>Staberoha cernua</i> (L.f.) Dur & Schinz	2/2	+	1/2	1/1	2/2	
<i>Restio paludosus</i> Pillans	1/2	1/2	+	1/1	1/2	
<i>Leucadendron salignum</i> Berg.		+	1/2	1/1	2/2	
<i>Elegia parviflora</i> Kunth	1/2	2/2	1/2		1/2	1/3
<i>Restio</i> sp. nov. 2		+			1/2	
<i>Willdenowia arescens</i> Kunth			2/2		1/2	
<i>Leptocarpus rigoratus</i> Mast.		1/2			1/2	2/3
<i>Chondropetalum rectum</i> (Mast.) Pillans		1/2				2/3
<i>Serruria burmanii</i> R.Br.		+		1/1	1/2	+
<i>Leptocarpus vimineus</i> (Rottb.) Pillans			+	1/1	1/2	+
<i>Restio cuspidatus</i> Thunb.			+	1/1	2/2	3/3
<i>Restio</i> sp. nov. 3			+			1/3
<i>Thamnochortus fruticosus</i> Berg.			+			1/3
<i>Willdenowia striata</i> Thunb.				+	+	+

laris). Scattered proteoid, ericoid and other shrubs (e.g. *Leucadendron salignum*, *Passerina vulgaris*, *Berzelia abrotanoides*, *Anthospermum aethiopicum*, *Rhus angustifolia*, *Diospyros glabra*) emerged to 1,2 m.

2. Habitat similarity

Table 1 shows sets of Proteaceous and Restionaceous associates for the study species. The column sequence in Table 1 interrelates the study species on the basis of associates shared, owing to the arrangement of rows and columns. Table 2 shows percentage similarity between these sets.

Similarity values were generally low; the only pairs of species showing more than 30 % similarity between sets of associates were *Leucadendron floridum* with

TABLE 2

Percentage similarity between sets of associates for six study species of Proteaceae, using "between-population frequency" data on Proteaceous and Restionaceous associates (Table 1) to calculate the Czekanowski coefficient. The formula used was $\frac{2w}{A+B} \times 100$ (Bray & Curtis, 1957), where w = number of associate species in common, A = number of associates for one study species, and B = number of associates for another study species.

	Study species					
	1	2	3	4	5	6
1. <i>Leucadendron floridum</i> R.Br.		36,4	15,1	21,3	20,0	3,9
2. <i>Leucadendron levisanus</i> (L.) Berg			29,3	11,4	15,8	15,0
3. <i>Serruria ciliata</i> R.Br.				27,3	17,0	4,1
4. <i>Diastella buekii</i> (Gandoger) Rourke					34,2	4,7
5. <i>Leucadendron flexuosum</i> Williams						17,4
6. <i>Leucadendron verticillatum</i> (Thunb.) Meisn. ...						

L. levisanus, and *Diastella buekii* with *Leucadendron flexuosum*. *Leucadendron verticillatum* and *L. flexuosum* had sets of associates largely different (17,4% similar) from each other and from those for the other two congeneric study species (3,9–20,0% similar). The set of associates for *Serruria ciliata* was more similar to that for *L. levisanus* (one of its associates) than to those for any other study species.

This numerical assessment of similarities can be viewed as a reflection of habitat similarity for the study species, based on the assumptions set out in the introduction. The habitats of the study species thus appear in general to be distinct from each other.

3. Discussion

Leucadendron levisanus, *L. floridum* and *Serruria ciliata* all formerly occurred in partial sympatry on the northern Cape Flats. Each of the remaining three study species was allopatric with all other study species.

Leucadendron levisanus and *L. floridum*, largely sympatric, have been recorded from the same localities (Williams, 1972). A difference in their habitats has, however, been hinted at in the literature: *L. levisanus* has been recorded from "sandy soil, often very damp in winter", while *L. floridum* "is always found growing near to streams or in damp places . . . it will grow with its roots submerged for long periods in waterlogged ground" (Williams, 1972). The chief habitat difference between these two congeners thus appears to be their different, although possibly overlapping, tolerance ranges with regard to soil moisture. *Serruria ciliata* evidently also has a discrete association with relatively poorly drained substrates, ranging from those supporting *L. levisanus* to better drained sands supporting the very habitat-specific *Chondropetalum acockii* (the habitats of

Chondropetalum acockii and *Restio micans*, associates respectively of *S. ciliata* and *L. levisanus*, have been described by Milewski & Esterhuysen, 1977).

The habitat of *Diastella buekii*, as expressed by its set of associates, is more similar to those for *L. levisanus* and *S. ciliata* than to that for *L. verticillatum*; the habitat of *Leucadendron flexuosum* appears equally similar to these two groups. The sand associated with *D. buekii*, probably of transported Table Mountain Sandstone origin, is apparently that of an intermontane alluvial plain, as is the substrate associated with *L. flexuosum*. However, *D. buekii* receives more than twice the average annual precipitation (800–900 mm, localities given by Rourke, 1976) received by *L. flexuosum* (300–400 mm, localities given by Williams, 1972), which grows on the edge of the Karoo.

The interrelationships of the habitats of the study species, thus interpreted from sets of associates, agree with the author's field impressions. The evident interrelationships of the vegetation associated with the study species, assessed subjectively on the basis of physiognomy and general floristics, also support these conclusions.

The main variation in the vegetation of the western flats appears to be in response to two edaphic gradients, the first determined by the proportions of sand and clay in the soil and the second by site drainage (e.g. Talbot, 1971; Taylor, 1969, 1972b, in press). The sand-clay ratio evidently results, at the extremes of the range, in the basic dichotomy outlined by Acocks (1975) and Taylor (in press), that of Coastal Fynbos (*Coastal Macchia*) on deep pale Tertiary sand and Coastal Rhenosterbosveld on clay-rich soil weathered from Malmesbury shale. *Leucadendron levisanus*, *L. floridum* and *Serruria ciliata* are species of the sand biotope, while *Leucadendron verticillatum* is a species of the clay biotope. *Leucadendron flexuosum* can perhaps be regarded as a species of an intermediate, relatively dry environment; *Diastella buekii* can perhaps be regarded as a species of a sandy environment intermediate between the Coastal Fynbos and Mountain Fynbos (i.e. Acocks' *Macchia* on Table Mountain Sandstone) biotopes.

The apparent dissimilarity between the habitats of the study species, including those which grow in geographical proximity in apparently similar environments, reflects the complex floristic pattern within Coastal Fynbos and Coastal Rhenosterbosveld. Preservation of as wide a range as possible of coastal flats endemics and the plant communities in which they occur calls for the strict preservation of all remaining relics of natural vegetation until a detailed phytocenological survey can provide the basis for optimal placing of permanent flora reserves.

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Appendix 1: Restionaceous and Proteaceous associates of *Serruria ciliata* var. *congesta* (100 plants investigated in 1 population).

Leucadendron salignum, *Protea scolymocephala*, *Serruria burmannii*, *Thamnochortus erectus*, *Thamnochortus fruticosus*, *Thamnochortus obtusus*, *Hypodiscus willdenowia*, *Elegia vaginulata*, *Willdenowia striata*, *Chondropetalum nudum* and *Restio cuspidatus*.